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THE USE OF ALTERNATING CURRENT FOR ELECTRIC HARDENING OF TOOLS AND MACHINE PARTS

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(Russian Editor's Note: Recently a number of conflicting viewpoints have been presented concerning the process of electric-spark hardening. Some organizations and individuals express doubt concerning the effectiveness of electric-spark hardening; at the same time, a large number of plants have successfully applied this method of hardening and have achieved significant savings. The process of electric-spark hardening is being accomplished by diverse enterprises in various ways and with differing electrical and other operating conditions. In view of the drive to save metals, especially high-speed steel, the editorial office of Vestnik Mashinostroyeniya considers it necessary to clarify the problem, and requests workers in plants and scientific institutions engaged in electric-spark hardening to express their opinions regarding the means of developing and the spheres of utilizing this method of hardening tools and machine parts.)

Surface hardening of iron and steel products, including a variety of tools, by means of an electrical discharge was discovered by Soviet researchers relatively long ago, but this type of processing has undergone general industrial appliation only in recent years. As a result of numerous research studies and practical observations, it has been established that the process of surface hardening metal objects by impulse electrical discharges forms a wear-resistant layer of special structure. This layer increases the durability of steel tools and machine parts. (The poorer the quality of heat treatment of the tool, the greater is the increase in durability. With high-quality tools, made of high-alloy steel, the increase in durability may be insignificant.)

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The formation of the hardened layer is a part of the complex of intricate physicochemical phenomena occurring in the area of the electrical discharge. The nature of these phenomena has not been completely investigated. Of the many hypotheses advanced in explanation of the processes taking place, two have received the widest circulation. According to the first, that of B. R. Lazarenko, hardening is achieved as a result of the polar transfer of the electrode material (anode) to the surface being hardened (cathode) by forces originating in the path of the spark discharge. The hardness of the surface being hardened results from the deposit of one or another hard alloy up on it. The process should be carried out with direct current only; otherwise, as B. R. Lazarenko claims, no polar transfer will occur.

According to the second hypothesis, hardening occurs as a result of an intricate process. Special attention is called to the following factors in the processing of steel:

1. The tempering of individual microscopic particles of the surface being hardened, which have been heated and individually fused by the heat given off during the electrical discharge. The speed of tempering reaches 10^3-10^6 degrees per second, which is unusual in generally accepted heat treatment and leads to deep structural changes in the surface layer.

2. The alloying of the molten steel with various elements through contact of the fused particles at both electrodes.

3. The formation of carbides and nitrides by the contact of the molten steel with carbon- and nitrogen-containing substances breaking down in the zone of discharge (air, electrode material, impurities, fluxes, etc.).

4. A secondary increase in hardness due to the dispersed segregation of the hardening phase in the process of solidifying the fusion and to the multiple heat effects of the subsequent discharges.

Present knowledge regarding these four processes does not permit precise determination as to which of its constituent parts is the main one.

The four enumerated processes can take place almost identically with either direct current of alternating current feeding the unit, simultaneous occurrence of all the processes not being compulsory for accomplishing the hardening effect; the presence of one or some of them is sufficient. However, because the phenomena associated with contact electrohardening have not been studied sufficiently, a conviction that an electrohardening unit must perforce be supplied with direct current has been widely held in technical circles until recently.

The use of alternating current, from the point of view of existing concepts concerning the polar transfer of metal, was considered inadmissible, as not providing the necessary technical effect. Hence, a number of organizations began to produce hardening units with built-in rectifiers which considerably increase the cost of the unit.

Furthermore, an examination of the results obtained by industry in the introduction of electrohardening, and an analysis of the theoretical conditions, indicate that there are no bases for limiting electrohardening to the use of direct current, and that the process can be accomplished on very simple units supplied by alternating current.

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Some data from the numerous observations concerning the effectiveness of electrohardening is given in the following table.

Effectiveness of Electrohardened Tools

Type of Tool	Durability of Hardened Tool as Compared With Unhardened Tool, in Percent	Type of Current	Compiler of Data
Cutters, 90 mm in diameter (EI262)	160-205	alternating	I. G. Kosmachev
Pneumatic chisels	150-300	alternating	P. I. Morshnev
End mills, 70 mm in diameter (RE1)	110-210	direct	I. G. Kosmachev
Saws for marble (U8)	175	alternating	L. A. Anagorskiy
Lathe tools (RF1)	180	direct	G. M. Kremerman
Through cutters (rezets prokhodnoy) (RF1)	300	alternating	P. I. Morshnev
Profile milling cutters, 105 mm in diameter (EI262)	190	alternating	P I. Morshnev
Various milling cutters	160	direct	G. M. Kremerman

As can be seen from the table, there is virtually no difference between the effectiveness of hardening with direct or alternating current, or the difference is so slight as to be negligible.

The research work conducted by A. V. Alekseyev and others also shows that the characteristics of hardened layers, whether obtained by alternating or direct current, are, for practical purposes, equal.

An analysis of the data presented by enterprises at the Leningrad conference on electrohardening shows that of 170 units studied, 30 operated on alternating current.

The conclusion that alternating current is suitable can be based also on an analysis of the phenomena occurring in electrohardening.

After the heat, given off as a result of the electrical impulse, fuses the contacting particles at the converging electrodes, subsequent changes in the metal do not depend on the type of current; they are determined only by the composition (massa) and the thermophysical properties of the materials used. Breaking down of the gas medium, solution of the carbon and nitrogen in the molten metal, or on the other hand, the decomposition of the carbides and nitrides, are purely thermochemical precesses and are determined solely by heat factors, regardless of the type of current generating the heat.

The transfer of material from one electrode to the other, and the diffusion phenomena associated with contact electrohardening, come about as a result of the contact of the particles of the molten metal of both electrodes under great specific pressure. This transfer also occurs regardless of the type of current by which the metal is fused.

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Finally, in operating on direct current, the discharge of the condenser has an oscillatory character in most cases, owing to the presence of an inductance discharge in the circuit, whereby the inverse half wave attains a significant magnitude. Thu', even in this case, the process actually taken place in part on alternating current.

From the above account it follows that if the some amount of heat is given off as a result of the impulse effect of either direct or alternating current, then both types of current must have an analogous effect on the surface of the contacting electodes, i.e., the same hardening effect.

Proceeding from this premise, which has been verified experimentally, it is possible substantially to simplify and reduce the cost of hardening units, utilizing alternating current directly for this purpose without first rectifying it.

As a result, the annual saving for a machine-building plant of medium size, with 10-15 units in operation, would amount to 10,000-15,000 rubles in the cost of the units alone. In addition, the use of alternating current units, together with the simplicity of their manufacture, would considerably facilitate and expedite the introduction of this method of hardening into industry.

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